BEST AVAILABLE COPY

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 October 2002 (03.10.2002)

PCT

(10) International Publication Number
WO 02/077411 A1

(51) International Patent Classification[7]: E21B 43/10, 33/134

(21) International Application Number: PCT/GB02/01395

(22) International Filing Date: 22 March 2002 (22.03.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/818,119 27 March 2001 (27.03.2001) US

(71) Applicant *(for all designated States except US)*: **WEATHERFORD/LAMB, INC.** [US/US]; 515 Post Oak Blvd, Suite 600, Houston, TX 77027 (US).

(71) Applicant *(for IS only)*: **HARDING, Richard, Patrick** [GB/GB]; Marks & Clerk, 4220 Nash Court, Oxford Business Park South, Oxford, Oxfordshire OX4 2RU (GB).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **LAURITZEN, J., Eric** [US/US]; 1607 Stoney Park Drive, Kingwood, TX 77339 (US).

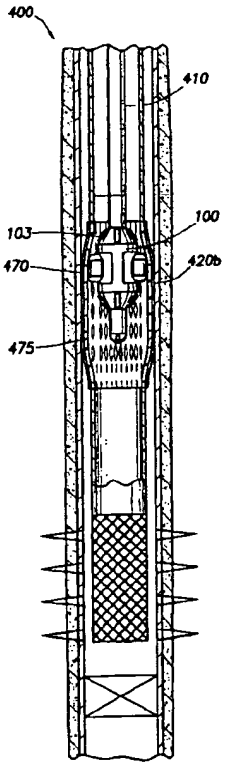
(74) Agents: **HARDING, Richard, Patrick** et al.; Marks & Clerk, 4220 Nash Court, Oxford Business Park South, Oxford, Oxfordshire OX4 2RU (GB).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),

[Continued on next page]

(54) Title: CREATION OF A DOWNHOLE SEAL



(57) Abstract: The present invention provides apparatus and methods for expanding tubulars in a wellbore. In one aspect, a process of sealing an annular area in a wellbore is provided in which a tubular (420a) having perforations (415) at a predetermined location and a sleeve (425) concentrically covering substantially all of the perforations is expanded into substantial contact with an inner diameter of a tubular (460), such as a casing or a liner. In another aspect, a process of sealing an annular area in a wellbore is provided in which a tubular having perforations at a predetermined location and a sleeve concentrically covering substantially all of the perforations is expanded into substantial contact with a junction between two tubulars, such as a liner and a casing, or between two liners.

WO 02/077411 A1



Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

CREATION OF A DOWNHOLE SEAL

This invention relates to downhole sealing, and to an apparatus and method for use in forming an arrangement to allow creation of a downhole seal. Generally, the invention relates to the provision of a seal or packer between concentric downhole tubing, such as a bore-lining casing and production casing.

In the oil and gas exploration and production industry, bores are drilled to access hydrocarbon-bearing rock formations. The drilled bores are lined with steel tubing, known as casing or liner, which is cemented in the bore. Oil and gas are carried from the hydrocarbon-bearing or production formation to the surface through smaller diameter production tubing which is run into the fully cased bore. Typical production tubing incorporates a number of valves and other devices which are employed, for example, to allow the pressure integrity of the tubing to be tested as it is made up, and to control the flow of fluid through the tubing. Further, to prevent fluid from passing up the annulus between the inner wall of the casing and the outer wall of the production tubing, at least one seal, known as a packer, may be provided between the tubing and the casing. The tubing will normally be axially movable relative to the packer, to accommodate expansion of the tubing due to heating and the like. The packer may be run in separately from the tubing, or in some cases may be run in with the tubing. In any event, the packer is run into the bore in a retracted or non-energized position, and at an appropriate point is energized or "set" to fix the packer in position and to form a seal with the casing. A typical packer will include slips which grip the casing wall and an elastomeric sealing element which is radially deformable to provide a sealing contact with the casing wall and which energizes the slips. Accordingly, a conventional packer has a significant thickness, thus reducing the available bore area to accommodate the production tubing. Thus, to accommodate production tubing of a predetermined diameter, it is necessary to provide relatively large diameter casing, and thus a relatively large bore, with the associated increase in costs and drilling time. Further, the presence of an elastomeric element in conventional packers limits their usefulness in high temperature applications.

Therefore, there is a need to provide a means of sealing production tubing relative to

casing which obviates the requirement to provide a conventional packer, by providing a relatively compact or "slimline" sealing arrangement.

In addition, some applications for packers now require high tensile strength and/or pressure ratings across the seal. These pressure ratings are conceivably as much as 10,000 psi (69 MPa) or higher. There is a further need, therefore, for a packer that results in an exceptionally high sealing strength.

Recent industry trends have demanded the need for expandable tubular systems, where tubulars are expanded *in situ*. A packer that utilizes this *in situ* expansion technology would therefore be advantageous.

In accordance with one aspect of the present invention there is provided an apparatus for sealing an annular area in a wellbore, comprising a tubular having perforations at predetermined locations in a wall thereof, a sleeve concentrically covering substantially all of the perforations, a first sealing member concentrically covering a top portion of an outer diameter of the sleeve, and a second sealing member concentrically covering a bottom portion of the outer diameter of the sleeve.

Further aspects and preferred features are set out in claim 2 *et seq*.

In one aspect, a method and apparatus for sealing an annular area in a wellbore is provided in which a tubular is placed in the wellbore, the tubular having perforations, or slots, at a predetermined location and a sleeve concentrically covering substantially all of the perforations. An expansion tool is placed in the tubular. The expansion tool is energised causing extendable members therein to extend radially to contact an inner wall of the tubular. The tubular is thereby expanded into substantial contact with an inner diameter of a casing or a liner, wherein substantially no gap exists between the sleeve and the casing or the liner.

In another aspect, a process of sealing an annular area in a wellbore is provided in which a tubular is placed in the wellbore at a junction between a casing and a liner or a junction between a liner and another liner. The tubular has perforations, or slots, at a

predetermined location and a sleeve concentrically covering substantially all of the perforations. An expansion tool is placed in the tubular. The expansion tool is energised causing extendable members therein to extend radially to contact an inner wall of the tubular. The tubular is thereby expanded into substantial contact with an inner diameter of the liner and/or casing.

In yet another aspect, a process of sealing an annular area in a wellbore is provided in which a tubular and an expansion tool assembly is placed in the wellbore, the tubular having perforations, or slots, at a predetermined location and a sleeve concentrically covering substantially all of the perforations. The expansion tool is energised causing extendable members therein to extend radially to contact an inner wall of the tubular, thereby expanding the tubular into substantial contact with an inner diameter of the liner and/or casing.

Some preferred embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an expansion tool;

Figure 2 is a perspective end view in section thereof;

Figure 3 is an exploded view of the expansion tool;

Figure 4a is a section view of a sealing apparatus including an expansion tool disposed on an end of a run-in tubular, a first tubular, a second perforated tubular, o-ring seals, and a bridge plug;

Figure 4b is a section view of the arrangement shown in Figure 4a, in which the second tubular has been partially expanded;

Figure 4c is a section view of the arrangement shown in Figures 4a-b, following expansion of the second tubular and removal of the expansion tool removed;

Figure 5a is a section view of a sealing apparatus, including an expansion tool disposed on an end of coil tubing at a junction between a first tubular and a second tubular having perforated section;

Figure 5b is a section view of the arrangement shown in Figure 5a, in which the second tubular has been partially expanded;

Figure 5c is a section view of the arrangement shown in Figures 5a-b, following expansion of the second tubular and removal of the expansion tool;

Figure 6 is a section view of an expansion tool disposed on an end of a run-in tubular, and a section of perforated tubular inserted into a wellbore as an assembly to create a seal between a junction of two tubulars; and

Figure 7 is a top view of a tubular partially expanded into a larger tubular so as to hang the smaller tubular.

Figures 1 and 2 are perspective views of an expansion tool 100 and Figure 3 is an exploded view thereof. The expansion tool 100 has a body 102 which is hollow and generally tubular with connectors 104 and 106 for connection to other components (not shown) of a downhole assembly. The connectors 104 and 106 are of a reduced diameter (compared to the outside diameter of the longitudinally central body part 108 of the tool 100), and together with three longitudinal flutes 110 on the central body part 108, allow the passage of fluids between the outside of the tool 100 and the interior of a tubular therearound (not shown). The central body part 108 has three lands 112 defined between the three flutes 110, each land 112 being formed with a respective recess 114 to hold a respective roller 116. Each of the recesses 114 has parallel sides and extends radially from the radially perforated tubular core 115 of the tool 100 to the exterior of the respective land 112. Each of the mutually identical rollers 116 is near-cylindrical and slightly barreled. Each of the rollers 116 is mounted by means of a bearing 118 at each end of the respective roller for rotation about a respective rotational axis which is parallel to the longitudinal axis of the tool 100 and radially offset therefrom at 120-degree mutual circumferential separations around the central body 108. The bearings

118 are formed as integral end members of radially slidable pistons 120, one piston 120 being slidably sealed within each radially extended recess 114. The inner end of each piston 120 (Figure 1) is exposed to the pressure of fluid within the hollow core of the tool 100 by way of the radial perforations in the tubular core 115. In this manner, pressurized fluid provided from the surface of the well, via a tubular, can actuate the pistons 120 and cause them to extend outward and to contact the inner wall of a tubular to be expanded.

Figure 4a is a section view of a sealing apparatus including an expansion tool 100 disposed on an end of a run-in tubular 410, a perforated or slotted tubular 420a, o-ring seals 470, 475, and a bridge plug 450. The perforated section of tubular replaces the need for a conventional production packer. The tubular 420a has a thickness that is commensurate with a desired load strength, but has slots or perforations 415 in the tubular 420a. The slots or perforations 415 reduce the tangential strength of the tubular 420a, so less work is required to expand the tubular 420a than would be required for a solid tubular.

Generally, the wellbore 400 has a first tubular, or casing, 460 having production perforations 480 disposed therein. A second tubular of smaller diameter, or production tubular 440 having a perforated, or slotted, section of tubular 420a, and a screen 430 disposed on the end thereof, are run into the casing 460. The perforated tubular 420a is connected to the production tubular 440 by any conventional means. Tubular 420a has perforations 415 which may be slots of oval shape, diamond shape, or any other geometry that reduces tensile hoop stresses, and a sleeve 425 concentrically covering substantially all of the perforations 415. The sleeve 425 is made of a ductile material, such as copper, stainless steel, tempered chrome, or a thermoplastic, and has an elastomer outer coating, or skin 435. The sleeve may be shouldered into position or welded into position. A first sealing member 470, such as an o-ring, concentrically covers a top portion of the outer diameter of the sleeve 425, and a second sealing member 475 concentrically covers a bottom portion of the outer diameter of the sleeve 425.

The expansion tool 100 is run into the tubular 440, 420a by a run-in tubular 410, or coil

tubing, which may also be used to provide electrical power and hydraulic fluid to the expansion tool 100. Referring again to Figure 1, fluid pressure to actuate the rollers 116 of the expansion tool 100 is provided from the surface of the well through a run-in tubular 410, or coiled tubing string. The expander tool 100 includes at least one aperture 101 at a lower end thereof. Aperture 101 permits fluid to pass through the apparatus and to circulate back to the surface of the well.

The tubular disposed around the apparatus could be a piece of production tubing, or liner or slotted liner which requires either the expansion of a certain length thereof or at least a profile formed in its surface to affix the tubular within an outer tubular or to facilitate use with some other downhole tool. In Figure 4a, the annulus 490 between the tubular 440, 420a and the wellbore 400 could be a void or could be filled with non-cured cement.

In use, the expansion tool 100 is lowered into the wellbore 400 to a predetermined position and thereafter pressurized fluid is provided in the run-in tubular 410. In the preferred embodiment, some portion of the fluid is passed through an orifice or some other pressure increasing device and into the expansion tool 100 where the fluid urges the rollers 116 outwards to contact the wall of the tubular 420a therearound. The expansion tool 100 exerts forces against the wall of a tubular 420a therearound while rotating and, optionally, moving axially within the wellbore 400. The result is a tubular that is expanded past its elastic limits along at least a portion of its outside diameter. Gravity and the weight of the components urges the expansion tool 100 downward in the wellbore 400 even as the rollers 116 of the expander tool 100 are actuated. The expansion can also take place in a "bottom up" fashion by providing an upward force on the run-in tubular string. A tractor (not shown) may be used in a lateral wellbore or in some other circumstance when gravity and the weight of the components are not adequate to cause the actuated expansion tool 100 to move downward along the wellbore 400. Additionally, the tractor may be necessary if the tool 100 is to be used to expand the tubular 420a wherein the tractor provides upward movement of the expansion tool 100 in the wellbore 400.

At an upper and a lower end of the expansion tool 100 shown in Figures 4a-b, 5a-b and

6 is a plurality of non-compliant rollers 103 constructed and arranged to initially contact and expand a tubular prior to contact between the tubular and fluid actuated rollers 116. Unlike the compliant, fluid actuated rollers 116, the non-compliant rollers 103 are supported only with bearings and they do not change their radial position with respect to the body portion of the tool 100.

Figure 4b is a section view of the embodiment shown in Figure 4a, wherein the tubular 420b has been partially expanded by the expansion tool 100 into an inner diameter of the casing 460.

Figure 4c is a section view of the embodiment shown in Figures 4a-b, wherein the tubular 420c has been expanded into the casing 460 and the extension tool 100 removed. The junction between the tubular 420c and the inner diameter of the casing 460 has been substantially sealed and is structurally supported in this manner. Sealing members 470, and 475 further reinforce the seal at the top and bottom portions of the outer diameter of the sleeve 425 creating a "zero interference fit" between the tubular 420c and the casing 460. The sleeve 425 is essentially sandwiched between the inner diameter of the casing 460 and the outer diameter of the perforated tubular 420c. Preferably, no gap exists between the sleeve 425 and the casing 460. With the casing 460 now supporting the sleeve 425, the collapse strength of the sleeve 425 and tubular 420a is enhanced because the material must shear to fail rather than buckle. The constrained tubular 420c has a collapse strength of about two and a half times of the unexpanded tubular 420a. Additionally, the constrained tubular 420c and sealing members 470, and 475 can withstand pressure exerted in the annulus 490 above and below the junction, as well as the constrained tubular 420c, or combinations thereof, of up to about 10,000 psi (69 MPa). It is also contemplated that this aspect of the invention would have valuable application at higher pressures of up to about 15,000 psi (103 MPa), such as in deep water operations.

Figure 5a is a section view of a sealing apparatus, including an expansion tool 100 disposed on an end of coil tubing 510, or a run-in tubular, a junction 530 between a first tubular 560, such as a casing or a liner, and a second tubular 540 having a perforated or slotted tubular section 520a. In this aspect, the perforated section of tubular will replace

the need for a conventional liner top packer.

Generally, the wellbore 500 has a first tubular 560, such as a casing or a liner. A second tubular of smaller diameter, or liner 540, having a perforated, or slotted, section of tubular 520a disposed at the top end thereof is run into the first tubular 560. The perforated tubular 520a is connected to the second tubular 520 by any conventional means and is made of the same material described in reference to Figures 4a-c. The perforated tubular 520a has perforations or slots 515, a sleeve 525 substantially covering the perforations, and an outer skin 535. The liner 540 is set with a conventional hanger assembly 580.

A mud motor 590 provides rotational forces to the expansion tool 100. The structure of the mud motors is well known. The mud motor can be a positive displacement Moineau-type device and includes a lobed rotor that turns within a lobed stator in response to the flow of fluids under pressure in the coiled tubing 510. The mud motor 590 provides rotational force to rotate the expansion tool 100 in the wellbore 500 while the rollers 116 are actuated against an inside surface of the tubular 520a. Pressurized fluid passes through the mud motor 590 providing rotational movement to an output shaft (not shown) that is connected to the expansion tool 100 to provide rotation thereto. Alternatively, the liner 540 may be set by running the liner 540 and the expansion tool 100, disposed on an end of a run-in tubular, into the wellbore 500 as an assembly (as shown in Figure 6 and further discussed below). It should be understood that a coil tubing and mud motor may be used with the embodiments of the invention described in Figures 4a-c, as well.

Figure 5b is a section view of the embodiment shown in Figure 5a, wherein the perforated section of tubular 520b has been partially expanded into the first tubular 560. The perforated tubular 520b, disposed above the solid section of tubular 540, is expanded until the perforated tubular 520b, sleeve 525, and sealing members 570, and 575 are in substantial contact with the inner diameter of the first tubular 560.

Figure 5c is a section view of the embodiment shown in Figures 5a-b, wherein the perforated section 520c of the second tubular 540 has been expanded into the first

tubular 560 and the expansion tool 100 removed. Thereby sealing the junction 530 between the first and second tubulars 560, 540. Preferably, there is no gap between the sleeve 525 and the first tubular 560.

Figure 6 is a section view of a sealing apparatus, wherein the expansion tool 100 and a second tubular 540 having a section of perforated tubular 520a are placed into a wellbore as an assembly to create a seal between a junction 530 of two tubulars. The expansion tool 100 is disposed within the second tubular and held therein with a temporary, shearable connection 610. In one embodiment, the tool 100 and the tubular 540 are run into the wellbore 500 on a run-in tubular 620 which provides hydraulic fluid to the tool. The tubular 540 is then set by any conventional means or as described below with reference to Figure 7. The connection 610 is sheared by an upward force on the run-in tubular, the tool energized, and the perforated tubular 520a expanded.

Figure 7 is a top section view of an embodiment of the invention, wherein a second, smaller tubular 540, or liner, is partially expanded into a first tubular 560 to temporarily hang the second tubular. This embodiment is especially useful to set a liner in a wellbore without the use of a conventional liner hanger. To set the liner 540, the expansion tool 100 is energized and radially expands one or more sections 710 of the second tubular 540, disposed below the perforated section of tubular 520a, into the first tubular 560, thereby fixing the liner 540 in the wellbore. The unexpanded sections 720 of tubular 540 allow for the passage of fluid, such as cement. Depending upon the requirements of the operator, a fluid path may be left between the expanded tubular and the wellbore in order to provide a flow path for fluids, including cement. For example, the tubular may be expanded in a spiral fashion leaving flute-shaped spaces for the passage of cement or other fluids. The perforated section of tubular 520a is then expanded to create a seal between the two tubulars. Optionally, the second tubular 540 may be expanded to smooth out the one or more sections 710 after cementing and the tubulars 540 and 520a may then be expanded in a "bottom-up" fashion. It should be understood that the method described herein is especially useful in the embodiments of Figures 5a-c and 6.

While the foregoing is directed to the preferred embodiment of the present invention,

other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

CLAIMS:

1. An apparatus for sealing an annular area in a wellbore, comprising:

a tubular having perforations at predetermined locations in a wall thereof;

a sleeve concentrically covering substantially all of the perforations;

a first sealing member concentrically covering a top portion of an outer diameter of the sleeve; and

a second sealing member concentrically covering a bottom portion of the outer diameter of the sleeve.

2. An apparatus as claimed in claim 1, wherein the first and second sealing members are o-rings.

3. An apparatus as claimed in claim 1 or 2, wherein the perforations are diamond slots or oval slots.

4. An apparatus as claimed in claim 1, 2 or 3, wherein the sleeve comprises:

a ductile material; and

an elastomer outer coating.

5. An apparatus as claimed in claim 4, wherein the ductile material is copper, stainless steel, tempered chrome, or a thermoplastic.

6. An apparatus for sealing an annular area in a wellbore, comprising:

a tubular having perforations at predetermined locations in a wall thereof;

a means for covering substantially all of the perforations; and

a first and a second means for sealing a top portion and a bottom portion between an outer diameter of the tubular and an inner diameter of the wellbore.

7. An apparatus as claimed in claim 6, wherein the means for covering is a sleeve concentrically covering substantially all of the perforations.

8. An apparatus as claimed in claim 6 or 7, wherein the first and second means for sealing are o-ring seals.

9. A method of sealing an annular area in a wellbore, comprising:

placing a tubular in the wellbore, the tubular having perforations at a predetermined location and a sleeve concentrically covering substantially all of the perforations;

placing an expansion tool in the tubular, the expansion tool disposed on a run-in string of tubulars;

energizing the expansion tool and causing extendable members therein to extend radially to contact an inner wall of the tubular; and

expanding the second tubular into substantial contact with an inner diameter of the wellbore, wherein substantially no gap exists between the sleeve and the wellbore.

10. A method as claimed in claim 9, further comprising:

placing a bridge plug disposed below the tubular.

11. A method as claimed in claim 9 or 10, wherein the run-in string of tubulars is a coiled tubing.

12. A method as claimed in claim 9, 10 or 11, wherein the wellbore is lined with a casing.

13. A method as claimed in claim 9, 10 or 11, wherein the wellbore is lined with a liner.

14. A method of sealing an annular area in a wellbore, comprising:

placing a first tubular in the wellbore;

placing a second tubular in the wellbore, the second tubular having perforations at a predetermined location and a sleeve concentrically covering substantially all of the perforations;

placing an expansion tool in the second tubular;

energizing the expansion tool and causing extendable members therein to extend radially to contact an inner wall of the second tubular; and

expanding the second tubular into substantial contact with an inner diameter of a junction between the first tubular and the second tubular.

15. A method as claimed in claim 14, further comprising:

hanging the second tubular by radially expanding one or more non-perforated sections of the second tubular into contact with a wall of the first tubular.

16. A method as claimed in claim 14 or 15, wherein the second tubular and the expansion tool are placed in the wellbore as an assembly.

17. A method as claimed in claim 14, 15 or 16, wherein the first tubular is a casing.

18. A method as claimed in claim 14, 15 or 16, wherein the first tubular is a liner.

19. A method as claimed in any of claims 14 to 18, further including circulating cement between the tubulars.

20. An apparatus for sealing an annulus area formed between the apparatus and a wellbore therearound, the apparatus comprising:

a slotted tubular having means for connection to another tubular at a first end; and

a sleeve member disposed around, attached to the slotted tubular, and covering substantially all of the slots, whereby the apparatus is expandable by a radial outward force applied to an inner wall of the slotted tubular.

21. A method of sealing an annular area in a wellbore, comprising:

placing a tubular in the wellbore; the tubular having perforations at a predetermined location and a sleeve concentrically covering substantially all of the perforations;

placing a means for expanding the tubular within the wellbore; and

expanding the tubular into substantial contact with an inner diameter of the wellbore.

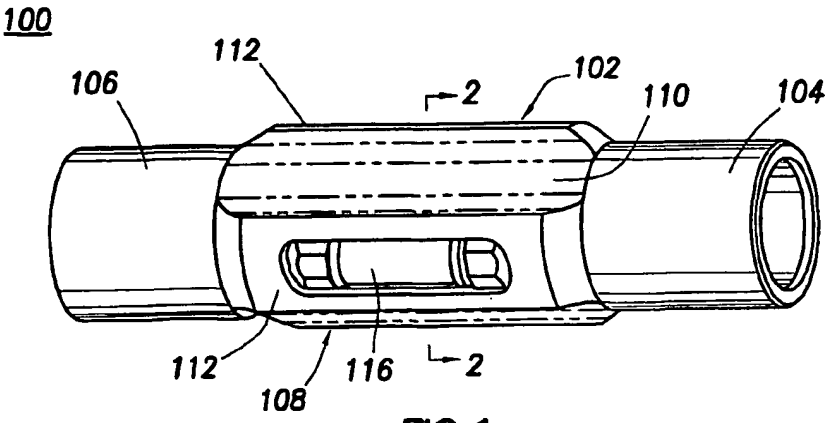


FIG. 1

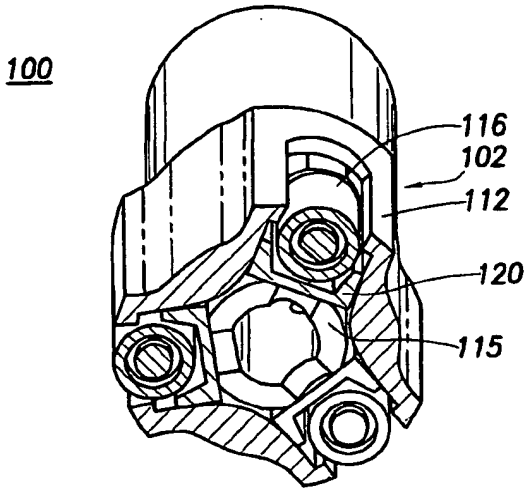


FIG. 2

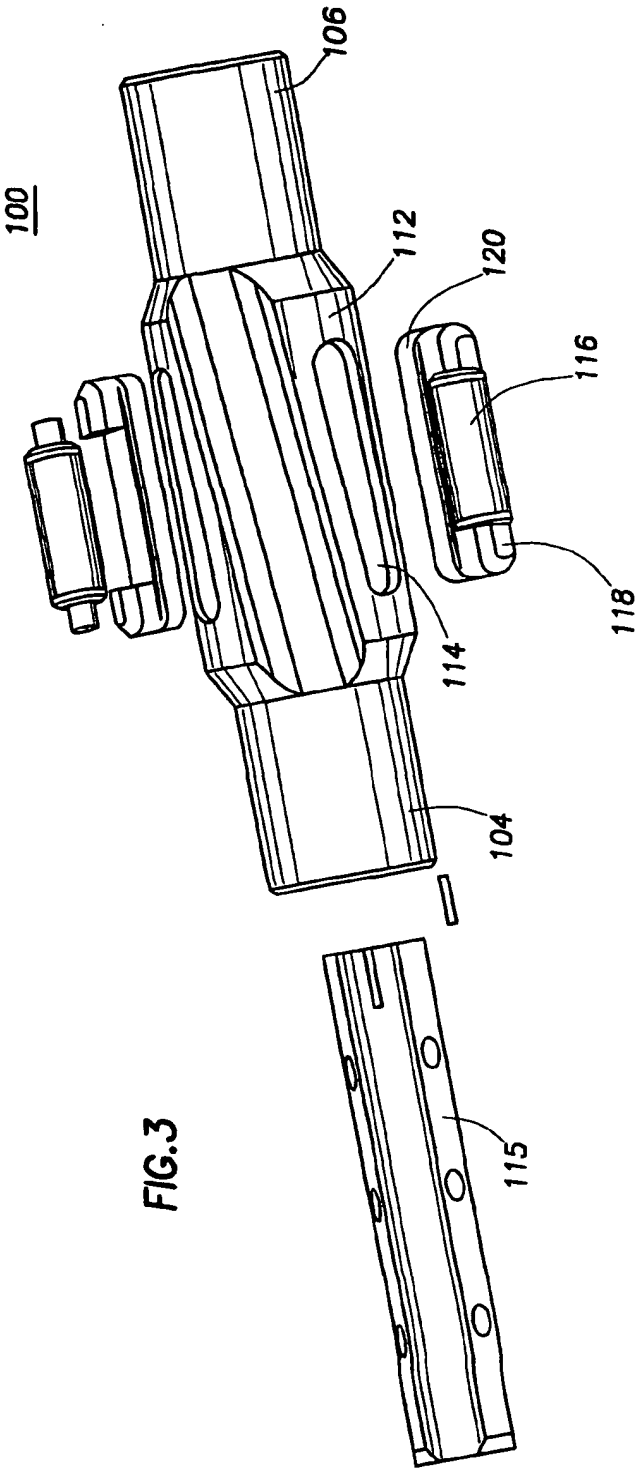


FIG.3

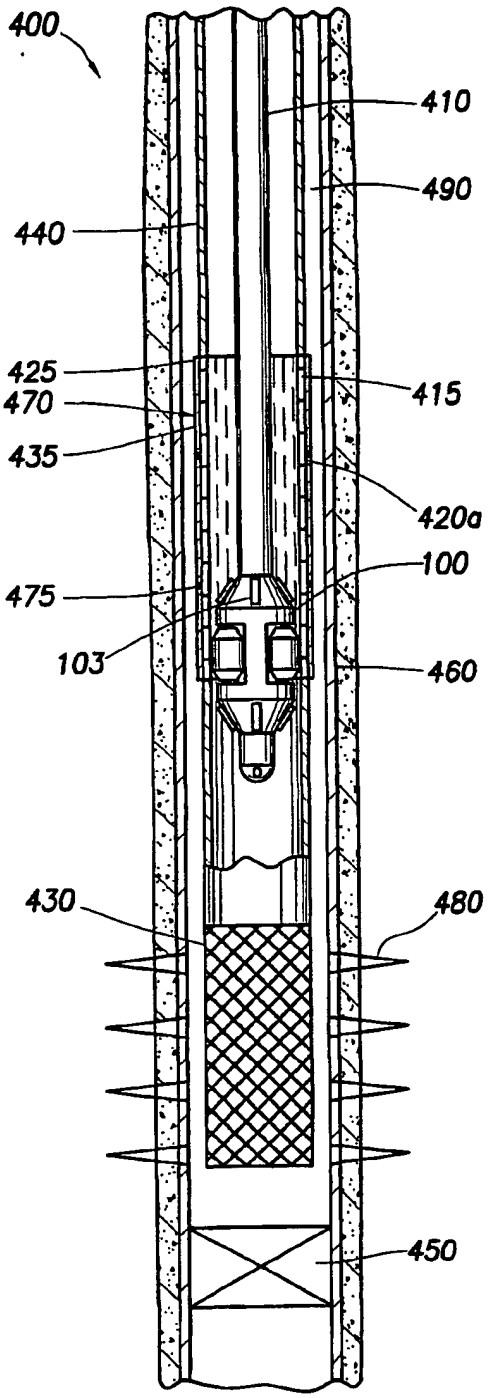

400
410
490
440
425
470
435
415
420a
100
475
103
460
430
480
450

FIG.4a

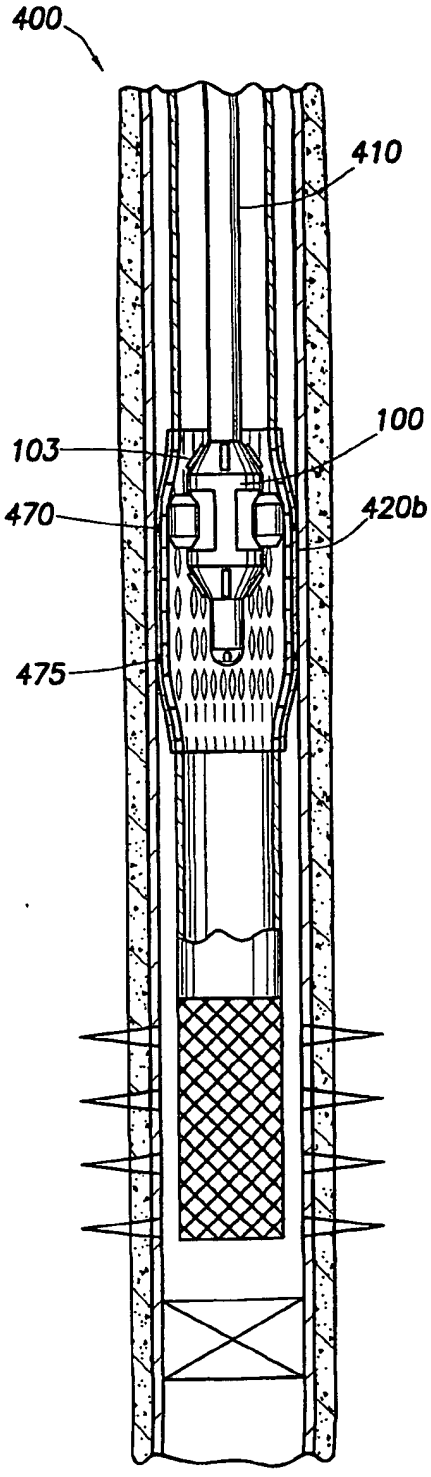

400
410
100
103
470
420b
475

FIG.4b

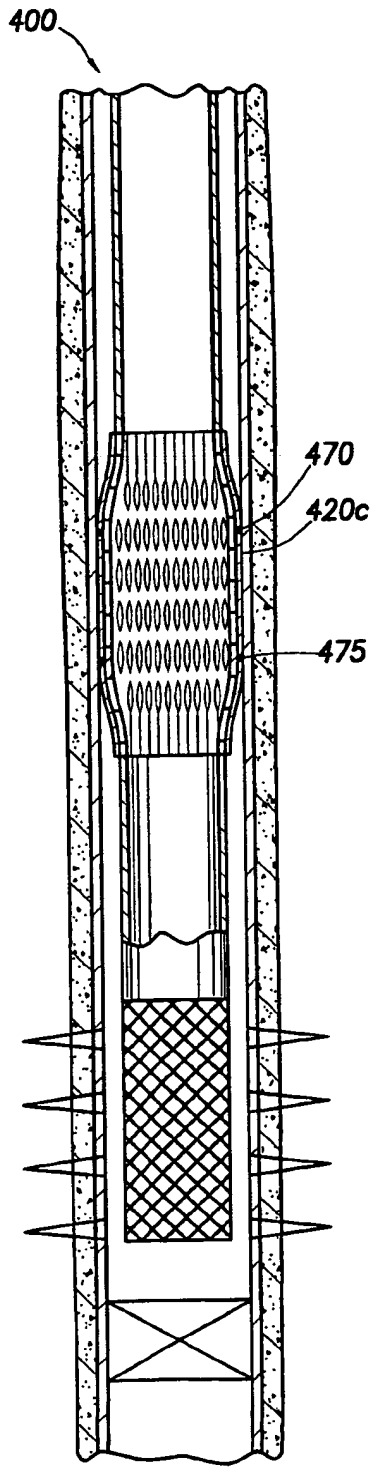

400
470
420c
475

FIG.4c

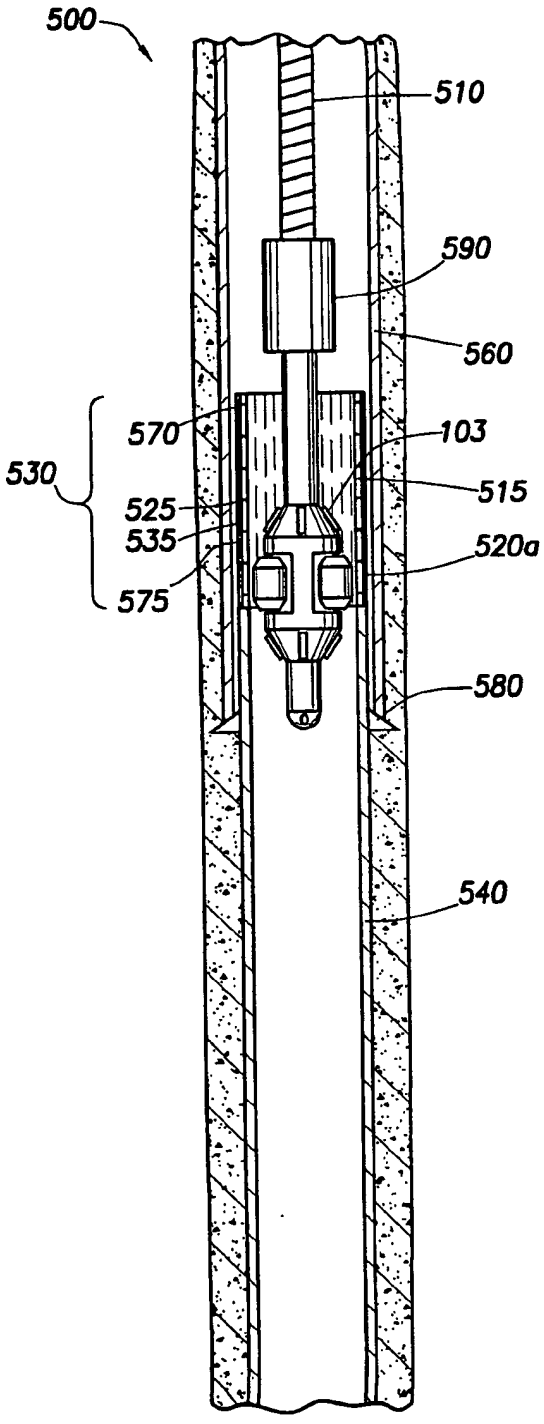

500
510
590
560
570
530
525
535
575
103
515
520a
580
540

FIG.5a

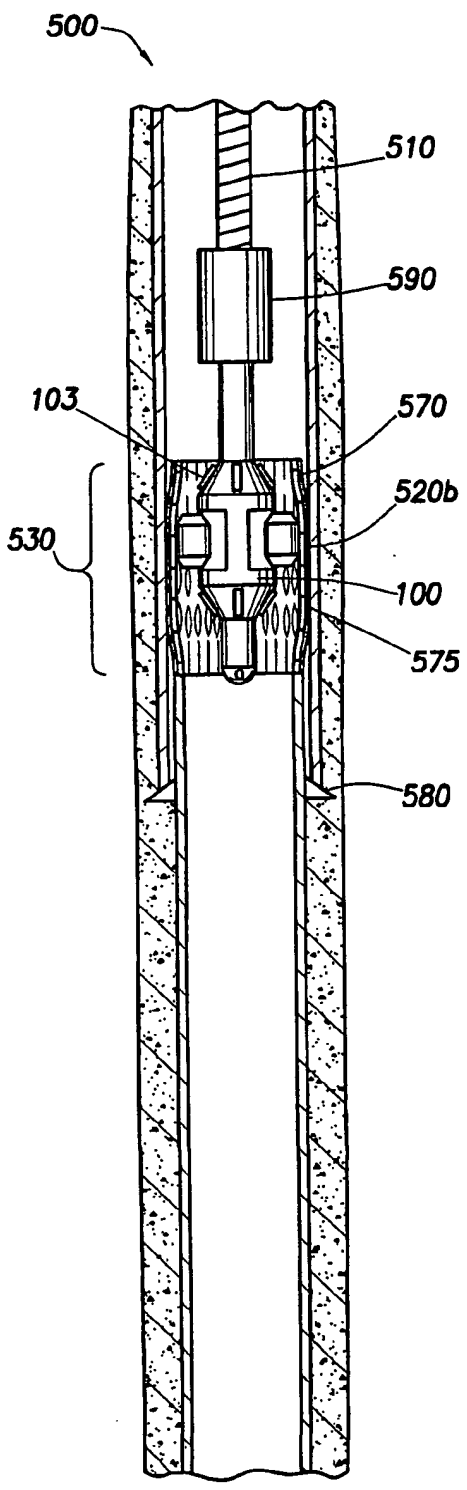


FIG.5b

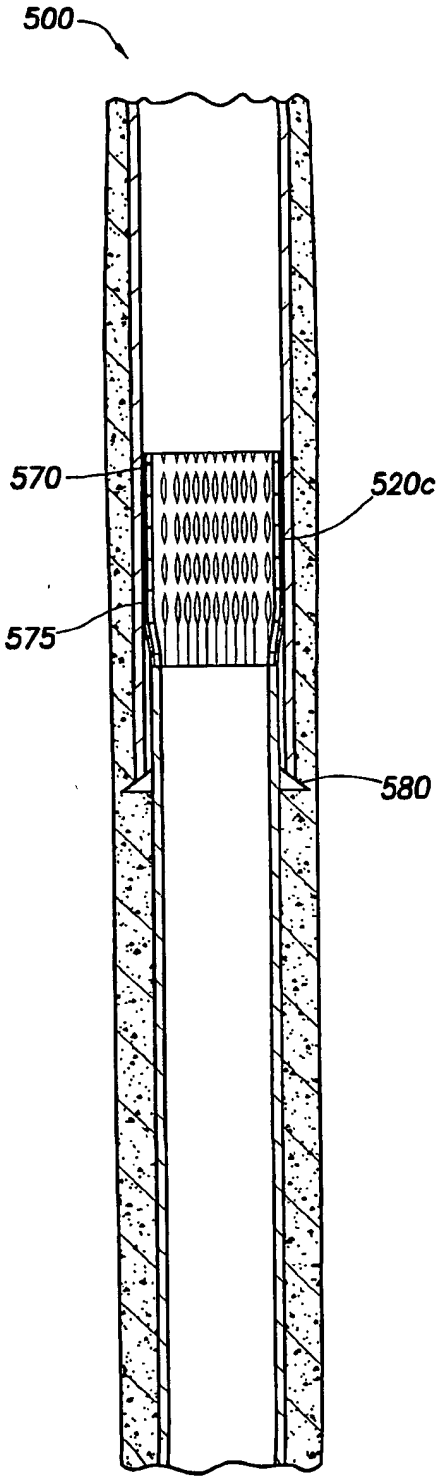


FIG.5c

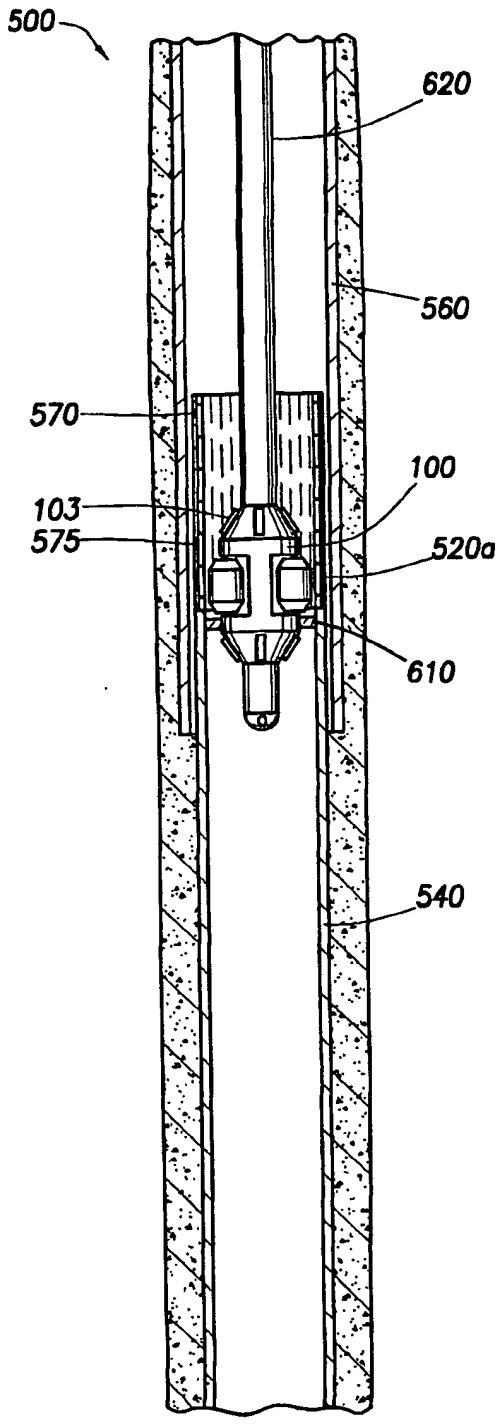


FIG.6

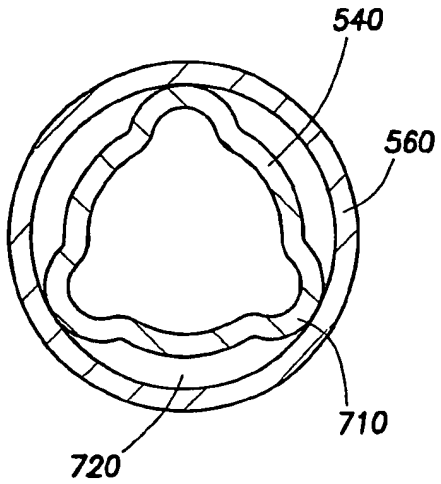


FIG.7

INTERNATIONAL SEARCH REPORT

PCT/GB 02/01395

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B43/10 E21B33/134

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 203 483 A (VINCENT RENIC P) 31 August 1965 (1965-08-31) column 3, line 24 - line 28; figure 3	1,6,9, 14,20,21
A	WO 00 50732 A (SHELL OIL CO) 31 August 2000 (2000-08-31) abstract; figures	1
A	GB 2 336 383 A (BAKER HUGHES INC) 20 October 1999 (1999-10-20) abstract; figures	1
A	US 6 189 616 B1 (GANO JOHN C ET AL) 20 February 2001 (2001-02-20) figures 8-10	1

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 September 2002	17/09/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Weiand, T

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98 42947 A (PETROLINE WELLSYSTEMS LTD ;METCALFE PAUL D (GB)) 1 October 1998 (1998-10-01) abstract; figures	1

INTERNATIONAL SEARCH REPORT

PCT/GB 02/01395

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3203483 A	31-08-1965	US 3179168 A	20-04-1965
		US 3203451 A	31-08-1965
WO 0050732 A	31-08-2000	AU 3603800 A	14-09-2000
		BR 0008470 A	05-02-2002
		EP 1155218 A1	21-11-2001
		NO 20014038 A	20-08-2001
		WO 0050732 A1	31-08-2000
		US 6253850 B1	03-07-2001
GB 2336383 A	20-10-1999	AU 2373399 A	21-10-1999
		NO 991765 A	15-10-1999
		US 6263972 B1	24-07-2001
US 6189616 B1	20-02-2001	US 6135208 A	24-10-2000
		EP 0961007 A2	01-12-1999
WO 9842947 A	01-10-1998	AU 735952 B2	19-07-2001
		AU 6739298 A	20-10-1998
		EP 0968351 A1	05-01-2000
		WO 9842947 A1	01-10-1998
		NO 994591 A	16-11-1999

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☑ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.